WHAT IS CLAIMED IS:

1   1.   A method for performing a fractional shift of transformed data,

2   comprising:

3   providing at least one fractional shift transform matrix in non-volatile storage

4   that is capable of fractionally shifting data by a shift factor;

5   receiving the transformed data; and

6   applying the at least one fractional shift transform matrix to the transformed

7   data to generate output transformed data that is fractionally shifted by the shift factor

8   without inverse transforming the transformed data.

1   2.   The method of claim 1, wherein the transformed data comprises image

2   data.

1   3.   The method of claim 1, wherein the transformed data includes data

2   that has been downsampled.

1   4.   The method of claim 1, wherein the shift factor is between zero and

2   one.

1   5.   The method of claim 1, wherein the non-volatile storage includes

2   matrices having different shift factors to perform the fractional pel shift at different

3   shift factors.

1   6.   The method of claim 1, wherein the transformed data is transformed

2   by applying a Forward Discrete Cosine Transform (FDCT) to an input data stream.

1   7.   The method of claim 6, wherein the input data stream was encoded

2   performing entropy encoding after applying the FDCT and quantization.

1   8.   The method of claim 7, further comprising:

2   entropy decoding the received encoded data before applying the at least one

3   fractional shift transform matrix; and

4   entropy encoding the output fractionally shifted transformed data.

1   9.   The method of claim 8, wherein the at least one fractional shift

2   transform matrix comprises three transformed matrices $\tilde{A}$, $\tilde{B}$, and $\tilde{C}$ that are applied

3   to vectors $\tilde{G}_1$, $\tilde{G}_2$,..., $\tilde{G}_m$ from the entropy decoded encoded data, wherein the output

4   encoded data is generated using two functions comprising:

5
$$\tilde{H}_k = \tilde{A} \bullet \tilde{G}_k + \tilde{B} \bullet \tilde{G}_{k+1} \quad \text{for k} = 1, 2, ..., m\text{-}1$$

6
$$\tilde{H}_k = \tilde{C} \bullet \tilde{G}_k \quad\quad \text{for k} = m,$$

7   wherein the output encoded data comprises an mxm matrix of the vectors $\tilde{H}_1$,

8 $\tilde{H}_2$,....,$\tilde{H}_m$.

1   10.   The method of claim 8, wherein the fractional shift is collocated on a

2   first data point in the encoded data to fractionally shift the data.

1   11.   The method of claim 9, wherein the transform matrices $\tilde{A}$, $\tilde{B}$, and $\tilde{C}$

2   are modified to accomplish dequantization and requantization of the vectors $\tilde{G}_1$,

3   $\tilde{G}_2$,..., $\tilde{G}_m$ and $\tilde{H}_1$, $\tilde{H}_2$,....,$\tilde{H}_m$, respectively.

1   12.   The method of claim 1, wherein each fractional shift transform matrix

2   is generated by applying a two-dimensional Forward Discrete Cosine Transform

3   (FDCT) to a fractional shift matrix including the shift factors.

1   13.   The method of claim 1, wherein the received and output encoded data

2 is encoded using one of the Joint Photographic Experts Group (JPEG) or Moving

3 Pictures Expert Group (MPEG) compression techniques.

1   14.   The method of claim 1, wherein the steps of providing the at least one

2 transformed matrix, receiving the input data stream, and applying the at least one

3 transformed matrix are performed by a printer.

1   15.   The method of claim 1, further comprising:

2   decoding the output encoded data; and

3   rendering the decoded data on an output device.

1   16.   The method of claim 15, wherein the output devices is a member of a

2 set of output devices comprising a printer, display monitor, and storage.

1   17.   The method of claim 1, wherein the fractional shift matrix is modified

2 to accomplish dequantization and requantization of the transformed data without

3 inverse transforming the transformed data.

1   18.   A system for performing a fractional shift of transformed data,

2 comprising:

3   a non-volatile storage;

4   at least one fractional shift transform matrix represented in the non-volatile

5 storage that is capable of fractionally shifting data by a shift factor;

6   means for receiving the transformed data;

7   means for applying the at least one fractional shift transform matrix to the

8 transformed data to generate output transformed data that is fractionally shifted by the

9 shift factor without inverse transforming the transformed data.

1   19.   The system of claim 18, wherein the transformed data comprises

2 image data.

1   20.   The system of claim 18, wherein the transformed data includes data

2 that has been downsampled.

1   21.   The system of claim 18, wherein the shift factor is between zero and

2 one.

1   22.   The system of claim 18, wherein the non-volatile storage includes

2 matrices having different shift factors to perform the fractional pel shift at different

3 shift factors.

1   23.   The system of claim 18, wherein the transformed data is transformed

2 by applying a Forward Discrete Cosine Transform (FDCT) to an input data stream.

1   24.   The system of claim 23, wherein the input data stream was encoded

2 performing entropy encoding after applying the FDCT and quantization.

1   25.   The system of claim 24, further comprising:

2   means for entropy decoding the received encoded data before applying the at

3 least one fractional shift transform matrix; and

4   means for entropy encoding the output fractionally shifted transformed data.

1   26.   The system of claim 18, wherein each fractional shift transform matrix

2 is generated by applying a two-dimensional Forward Discrete Cosine Transform

3 (FDCT) to a fractional shift matrix including the shift factors.

1   27.   The system of claim 18, wherein the steps of providing the at least one

2   transformed matrix, receiving the input data stream, and applying the at least one

3   transformed matrix are performed by a printer.

1   28.   The system of claim 18, further comprising:

2   decoding the output encoded data; and

3   rendering the decoded data on an output device.

1   29.   The system of claim 28, wherein the output devices is a member of a

2   set of output devices comprising a printer, display monitor, and storage.

1   30.   The system of claim 18, wherein the fractional shift matrix is modified

2   to accomplish dequantization and requantization of the transformed data without

3   inverse transforming the transformed data.

1   31.   An article of manufacture including code for performing a fractional

2   shift of transformed data, wherein the code causes operations to be performed, the

3   operations comprising:

4   providing at least one fractional shift transform matrix in non-volatile storage

5   that is capable of fractionally shifting data by a shift factor;

6   receiving the transformed data; and

7   applying the at least one fractional shift transform matrix to the transformed

8   data to generate output transformed data that is fractionally shifted by the shift factor

9   without inverse transforming the transformed data.

1   32.   The article of manufacture of claim 31, wherein the transformed data

2   comprises image data.

1   33.   The article of manufacture of claim 31, wherein the transformed data

2 includes data that has been downsampled.

1   34.   The article of manufacture of claim 31, wherein the shift factor is

2 between zero and one.

1   35.   The article of manufacture of claim 31, wherein the non-volatile

2 storage includes matrices having different shift factors to perform the fractional pel

3 shift at different shift factors.

1   36.   The article of manufacture of claim 31, wherein the transformed data

2 is transformed by applying a Forward Discrete Cosine Transform (FDCT) to an input

3 data stream.

1   37.   The article of manufacture of claim 36, wherein the input data stream

2 was encoded performing entropy encoding after applying the FDCT and

3 quantization.

1   38.   The article of manufacture of claim 37, further comprising:

2   entropy decoding the received encoded data before applying the at least one

3 fractional shift transform matrix; and

4   entropy encoding the output fractionally shifted transformed data.

1   39.   The article of manufacture of claim 38, wherein the at least one

2 fractional shift transform matrix comprises three transformed matrices $\tilde{A}, \tilde{B}$, and $\tilde{C}$

3 that are applied to vectors $\tilde{G}_1, \tilde{G}_2,..., \tilde{G}_m$ from the entropy decoded encoded data,

4 wherein the output encoded data is generated using two functions comprising:

5 $$\tilde{H}_k = \tilde{A} \cdot \tilde{G}_k + \tilde{B} \cdot \tilde{G}_{k+1} \quad \text{for } k = 1, 2, \ldots, m\text{-}1$$

6 $$\tilde{H}_k = \tilde{C} \cdot \tilde{G}_k \quad \text{for } k = m,$$

7 wherein the output encoded data comprises an *mxm* matrix of the vectors $\tilde{H}_1$,

8 $\tilde{H}_2,\ldots,\tilde{H}_m$.

1   40. The article of manufacture of claim 38, wherein the fractional shift is

2 collocated on a first data point in the encoded data to fractionally shift the data.

1   41. The article of manufacture of claim 39, wherein the transform

2 matrices $\tilde{A}$, $\tilde{B}$, and $\tilde{C}$ are modified to accomplish dequantization and requantization

3 of the vectors $\tilde{G}_1$, $\tilde{G}_2,\ldots$, $\tilde{G}_m$ and $\tilde{H}_1$, $\tilde{H}_2,\ldots,\tilde{H}_m$, respectively.

1   42. The article of manufacture of claim 31, wherein each fractional shift

2 transform matrix is generated by applying a two-dimensional Forward Discrete

3 Cosine Transform (FDCT) to a fractional shift matrix including the shift factors.

1   43. The article of manufacture of claim 31, wherein the received and

2 output encoded data is encoded using one of the Joint Photographic Experts Group

3 (JPEG) or Moving Pictures Expert Group (MPEG) compression techniques.

1   44. The article of manufacture of claim 31, wherein the steps of providing

2 the at least one transformed matrix, receiving the input data stream, and applying the

3 at least one transformed matrix are performed by a printer.

1   45.   The article of manufacture of claim 31, further comprising:

2   decoding the output encoded data; and

3   rendering the decoded data on an output device.

1   46.   The article of manufacture of claim 45, wherein the output devices is

2   a member of a set of output devices comprising a printer, display monitor, and

3   storage.

1   47.   The article of manufacture of claim 31, wherein the fractional shift

2   matrix is modified to accomplish dequantization and requantization of the

3   transformed data without inverse transforming the transformed data.